# PESTICIDE USAGE SURVEY REPORT 298

# POTATO STORES

# IN THE UNITED KINGDOM

# 2020

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If you have any enquiries or feedback on the statistics included in this report, they can be directed to the contact given below:

Pesticide Usage Survey Team – e-mail: PUS@fera.co.uk Telephone: 01904 465 712

Alternatively, please contact: Fera Science Ltd. at: science@fera.co.uk

**DATA USES**

The data are used for a number of purposes including:

- Quantifying pesticide usage and changes in the use of active substances over time;
- Policy, including assessing the economic and/or environmental implications of the introduction of new active substances and the withdrawal/non-authorisation of pesticide products (the data reported to organisations such as the OECD and EU enabling the United Kingdom to honour international agreements); evaluating changes in growing methods and Integrated Pest Management where this has an impact on pesticide usage;
- Informing the pesticide risk assessment (authorisation) process;
- Informing the targeting of monitoring programmes for residues in food and the environment;
- Contributing to assessing the impact of pesticide use, principally as part of the Pesticides Forum's Annual Report;
- Responding to enquiries (for example, Parliamentary Questions, correspondence, queries under the Freedom of Information Act or Environmental Information Regulations, etc.);
- Providing information to assist research projects which can support all the above activities;
- Training/teaching programmes which are designed to improve practice in the use of pesticides by the farming/training industries;
- Informing the Wildlife Incident Investigation Scheme (WIIS) programme to help identify potential misuse of pesticides.

**REVISIONS POLICY**

This report presents a comprehensive summary of data for potatoes harvested in 2020 and stored during 2020/2021. We will provide information on any revisions we make to the report or the datasets if any inaccuracies or errors occur. Details of any revisions, including the date upon which they were changed, will appear on the following website:

https://pusstats.fera.co.uk/home

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**OVERVIEW OF MAIN FINDINGS**

This report presents information on all aspects of pesticide usage during storage of potatoes harvested in 2020 and stored during 2020/2021. Data were collected predominantly by postal survey and telephone from 45 farm stores and from 128 merchant stores in the United Kingdom.

Compared to the previous survey, the number of farm stores has declined from 90 to 45, whereas the merchant stores have increased from 82 to 128. Whilst it is difficult to state the exact reasons for these changes, it is very likely that the reduction in farm stores is due to the Covid pandemic reducing participation. The increase in merchant stores reflects changing farming practice, where the practice of growers renting land and storing potatoes from other farms is increasing. These farms are classified as merchant stores.

Data collected on seed and ware potatoes from both farm and merchant stores are combined. This reflects changes in potato storage practice over the last decade, which has resulted in very little difference between the way in which farm and merchant stores are managed. In addition, data collection has changed over time (including pre-Covid) from a primarily visit survey to a combination of postal and telephone calls.

The estimated weight of ware potatoes stored from the 2020 harvest was approximately 3.1 million tonnes, of which this survey estimated that 62% received no post-harvest treatment (79% of the untreated crop was in refrigerated stores). The basic tonnage treated was 1.2 million tonnes, though some potatoes received multiple treatments. The total tonnage treated, which includes multiple treatments to the same tonnage, was 2.1 million tonnes.

The biggest change to stored ware potatoes in 2020 has been the loss of approval for chlorpropham and the increased use of the biopesticide spearmint oil as a replacement sprout suppressant. This has probably been the biggest change in potato storage since tecnazene lost approval in the early 2000s.

Between 2018 and 2020, the use of maleic hydrazide in the field increased by 65% in terms of area treated and 69% by weight applied. The use of maleic hydrazide in the field prevents the sprouting of potatoes in store. This increase in usage was due to growers anticipating the need to prevent sprouting in store, knowing that chlorpropham would not be available.

Spearmint oil, used as a potato sprout suppressant, accounted for 76% of the total tonnage of ware potatoes treated, while 23% were treated with ethylene, and less than 1% with both imazalil and thiabendazole. A total of 103.2 tonnes of active substances were used to treat ware potatoes. Spearmint oil accounted for almost all the total weight of active substances used, with both imazalil and thiabendazole comprising less than 1% of the weight of active substances applied. Ethylene gas does not normally have a weight of active substance associated with it and it is impossible to estimate the weight applied, as this depends on the store capacity, crop volume, the quality of store construction and the duration of storage.

From this survey, it is estimated that 32% of the 506,108 tonnes of the stored seed potatoes were treated, either on entry to the store or during the storage period, with a single application of pesticides. The formulations recorded were imazalil, thiabendazole and ethylene, accounting for 88%, 7% and 5% of the total tonnage treated respectively. In total, 2.4 tonnes of active substances were used, principally imazalil, 84% of the total weight and thiabendazole 16%. No weight of ethylene has been reported as information was only available from a limited number of stores.

A comparison is made between this survey and previous surveys conducted between 2006 and 2018.

The tonnage of ware potatoes stored each year is variable and is dependent on the areas grown, weather conditions and annual yields (see Figure 1).

In 2020 growing conditions were good and overall production increased. The percentage of the untreated tonnage increased from 57% in 2018 to 62% in 2020. The tonnage of ware potatoes stored and treated have tended to decrease over time: in 2020 the tonnage stored was 19% lower than in 2006 and the treated tonnage (including repeat applications) was 32% lower.

The weight of active substances applied to ware potatoes in 2020 was around 3.5 times greater than in 2018, entirely due to the higher rate of spearmint oil, which also makes it difficult to compare usage with previous years (see Figure 2). This substantial increase follows a gradual reduction in the weight of pesticides over the period 2006-2018. The tonnage of ware potatoes stored has decreased by 19%, with the treated tonnage (including repeat applications) declining by 32% and the weight of pesticides increasing by 1.87 times.

The total tonnage of stored seed potatoes in the United Kingdom decreased by 10% between 2018 and 2020, with the basic tonnage treated increasing by 67% over the same period (see Figure 3). This resulted in a 37% increase in the weight of active substances applied between the two years (see Figure 4).

Over the longer term (since 2006), the tonnage of seed potatoes both stored and treated has varied with no clear trend. In 2020, the tonnage stored was 21% higher than in 2006, whilst the basic tonnage treated was 7% higher.

The weight of active substances applied to seed potatoes in 2020 was similar to that seen in 2008 with considerably higher weights applied in some of the intervening years (Figure 4).

**INTRODUCTION**

The Expert Committee on Pesticides (ECP) advises government on all aspects of pesticide use. In order to discharge this function, the Committee must regularly monitor the usage of all pesticides. It needs accurate data on the usage of individual pesticides.

As part of the on-going process for obtaining data, the Pesticide Usage Survey Teams of:

- Fera Science Ltd., a joint venture between Capita PLC and the Department for Environment, Food & Rural Affairs (Defra);
- SASA, a division of the Scottish Government's Agriculture and Rural Delivery Directorate;
- and the Agri-Food & Biosciences Institute (AFBI), Department of Agriculture, Environment and Rural Affairs (DAERA)

conducted surveys of pesticide usage in potato storage from the 2020 harvest by contacting holdings throughout the United Kingdom during the winter of 2020/2021, with follow up contacts in May & June of 2021.

This was the sixth survey of usage on potato storage in the United Kingdom and the fifteenth survey of pesticide usage in potato stores carried out by the Great Britain Pesticide Usage Survey Teams. The previous report for the United Kingdom covered all pesticide usage on potatoes harvested and stored in 2018 (Garthwaite et. al., 2020). Other surveys of potato storage in the United Kingdom were conducted in 2010, 2012, 2014 and 2016.

https://pusstats.fera.co.uk/upload/xu5jPZHLHpL9r2E4H8y3RbxMSssAXg1aRtO2VdLl.pdf

Since 2010 all surveys of pesticide usage in agriculture and horticulture have been fully co-ordinated by the survey teams of England & Wales, Scotland and Northern Ireland. The methodology used for sample selection and the collection of data from sample holdings is identical in each region. Reports are produced of pesticide usage throughout the United Kingdom. All teams have undertaken United Kingdom Statistics Authority (UKSA) audits.

Information on all aspects of pesticide usage in the United Kingdom as a whole, or for Wales or the Defra regions of England, may be obtained from the Pesticide Usage Survey Team at Fera Science Ltd., Sand Hutton, York, YO41 1LZ, United Kingdom.

For further information please contact:

The survey team – e-mail: PUS@fera.co.uk Telephone: 01904 465 712

Or visit the website: https://pusstats.fera.co.uk/home

Alternatively, please contact: Fera at: science@fera.co.uk

Further data relating specifically to Scotland may be obtained from SASA. Also available at:

https://www.sasa.gov.uk/pesticides/pesticide-usage/pesticide-usage-survey-reports

Copies of reports on pesticide usage in Northern Ireland may be obtained from Her Majesty's Stationery Offices. Also available at:

https://www.afbini.gov.uk/articles/pesticide-usage-monitoring-reports

**INTRODUCTION (*cont*.)**

Previous reports for the United Kingdom, Great Britain, England & Wales and Northern Ireland can also be viewed and downloaded on the Internet at:

https://pusstats.fera.co.uk/home

Whilst Scotland, Northern Ireland and Wales are included within the report as individual countries, England is split into Government Office regions. See the link above for more information.

**DEFINITIONS AND APPROACHES USED IN THIS REPORT**

a) The term 'Applications' is used throughout this report to refer to the number of pesticide treatments applied to a store (whole or part).

b) 'Basic tonnes treated' is the gross weight of potatoes treated with pesticides excluding repeat applications, i.e. the total tonnes stored minus the untreated tonnage ('Tonnes untreated').

c) 'Total tonnage treated' is the gross weight of potatoes treated with pesticides including repeat applications, i.e. basic tonnes treated x number of applications.

d) 'Bulk stores' include loose potatoes in a variety of stores, as opposed to those stored in boxes. Potatoes stored in bags are excluded from this survey.

e) 'Unventilated ambient stores' include structures that are naturally ventilated and rely on convective ventilation.

f) 'Ventilated ambient stores' include structures using forced air ventilation. They do not use refrigeration.

g) 'Refrigerated stores' include structures using refrigeration; they may also have forced air ventilation.

h) 'Merchant' includes AHDB (Agriculture & Horticulture Development Board) Potatoes registered purchasers, who have traded 100 tonnes of potatoes or more in the most recent full crop year and qualify for payment of AHDB Potatoes levy and also farm owned stores storing potatoes from their own and other growers' holdings. They will have stored ware potatoes for a period of more than two months.

i) A 'Farm Store' holds only potatoes from the single holding where the store is located, for a period of more than two months (ware potatoes only).

j) In this report the term 'formulation(s)' is used to describe the pesticide active substance or mixture of active substances in a product(s).

k) 'Seed potatoes' are those stored and used for planting the next season's crop. Prior to planting, seed potatoes are placed in a 'chitting house' where the tuber can produce shoots and rootlets prior to planting.

l) For this report it has been assumed that 96% of all harvested seed potatoes are stored. These figures are based on the AHDB November stock figures and as such it is likely that most seed potatoes will have been stored for two months or more. The crop is stored before export or sales to other merchants and growers.

m) 'Ware potatoes' are those used for human consumption, including those processed by a manufacturer.

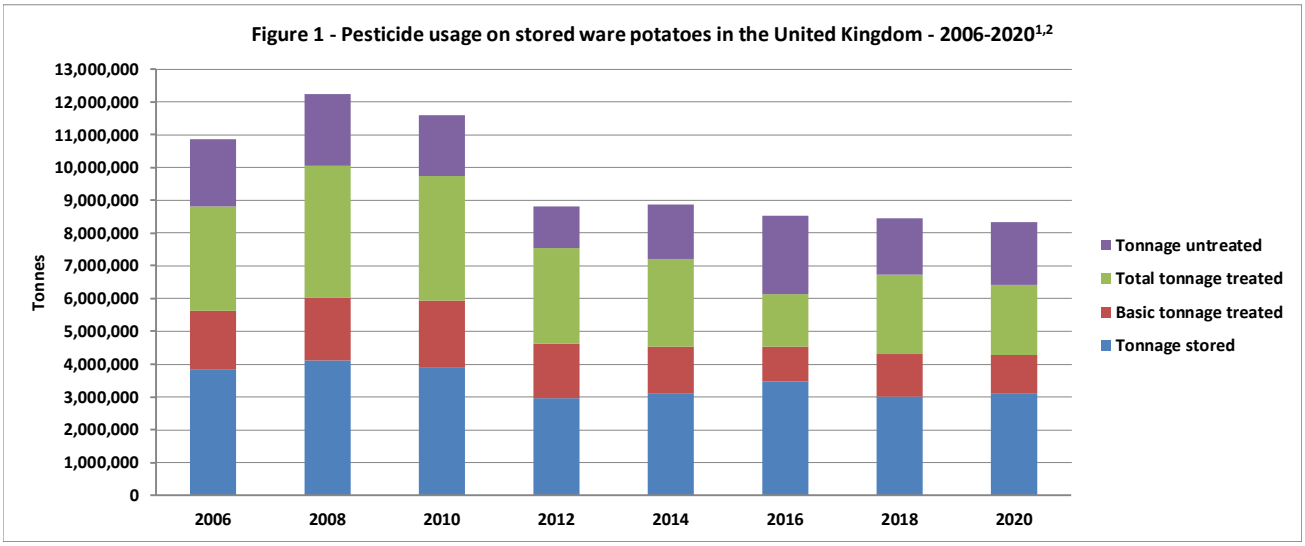
n) 'Arable crops' include cereals, combinable peas & beans, oilseed rape, linseed, potatoes and sugar beet.

o) There is no standard recommended rate per tonne of potatoes for the use of ethylene. The application equipment is pre-set to maintain the required level of ethylene concentration in each store. Consequently, the quantity of ethylene used will vary according to the store capacity, crop volume, the quality of store construction and the duration of storage. In most cases the actual amount of ethylene used was not available and it was not considered appropriate to include the information available from only a limited number of stores.

p) 'Storage' is defined as ware potatoes being in store for two months or longer. For seed potatoes, storage times may be shorter than this.

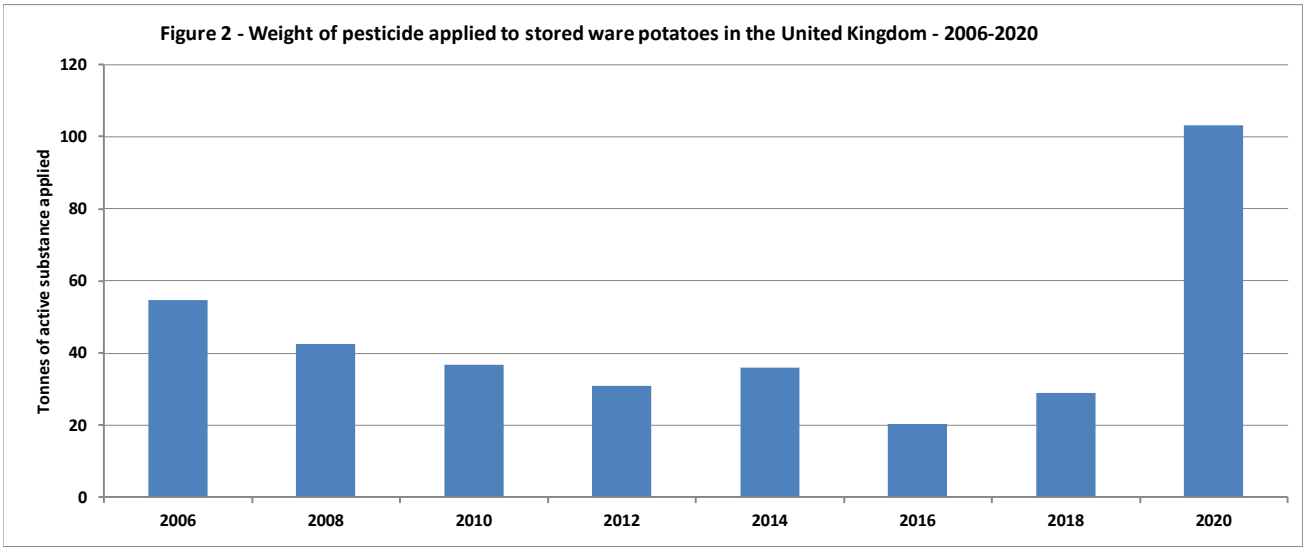
## TRENDS

## WARE POTATOES



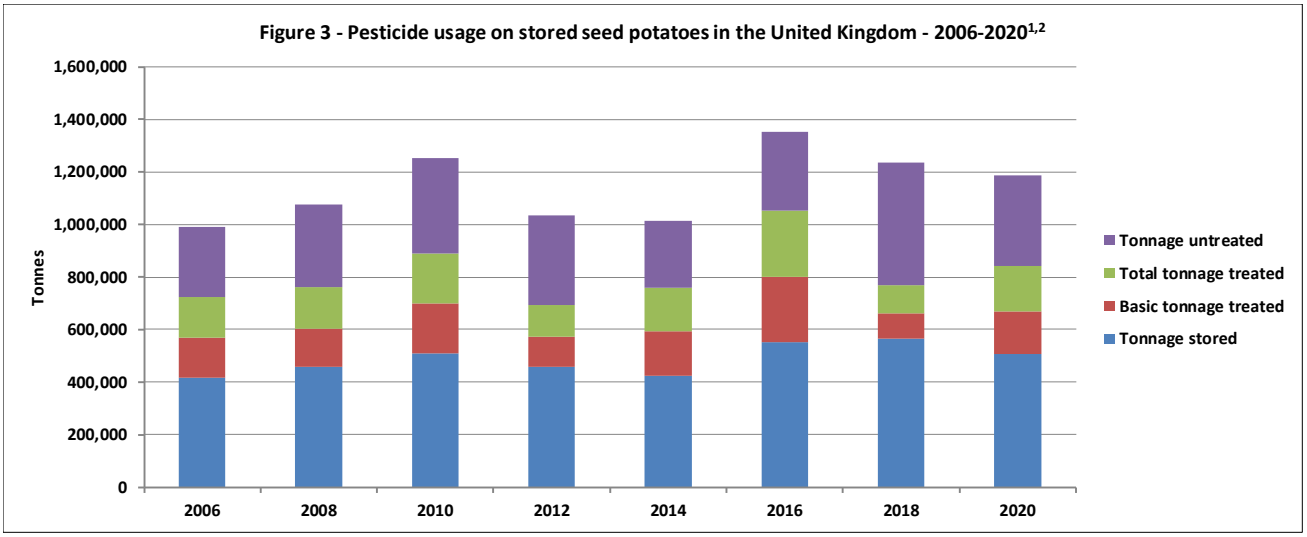

[1]The basic tonnage treated is the tonnage stored minus the untreated tonnage

[2]The total tonnage treated includes repeat applications



## TRENDS (Cont.)

## SEED POTATOES

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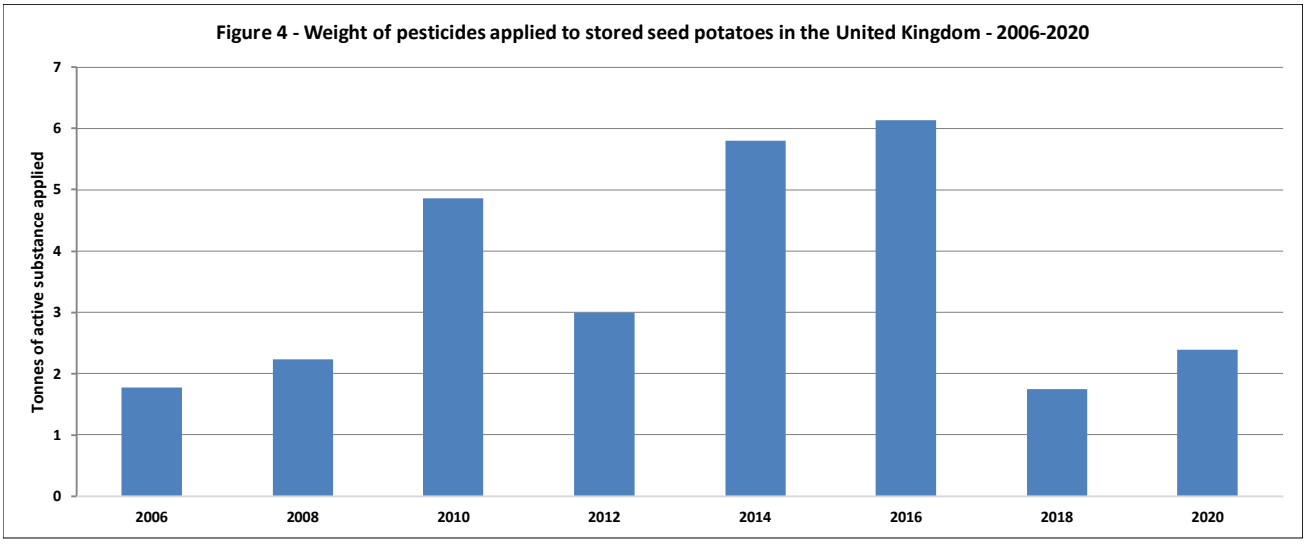
[2]The total tonnage treated includes repeat applications



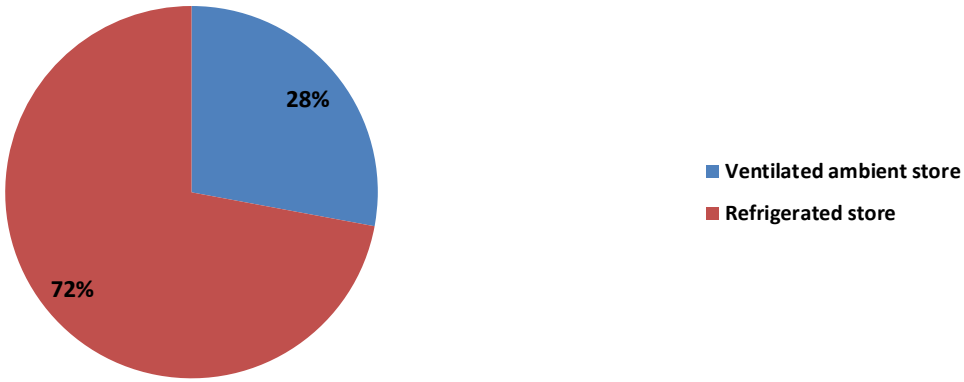
**WARE POTATOES**

- **An estimated 3,096,086 tonnes of ware potatoes were stored in the United Kingdom (this figure is based on GB November seed stock figures produced by AHDB combined with estimates from Northern Ireland and an additional factor to account for 'non-grower' stores (see later notes))**
- **126,704 ha of ware potatoes were grown in the United Kingdom in 2020**
- **An estimated 1,177,314 tonnes were treated with an average of 1.83 treatments resulting in a total treated tonnage of 2,149,001 tonnes**
- **A further 1,918,779 tonnes (62%) remain untreated (79% of these in refrigerated stores)**

***Ware potatoes – Storage methods***

Approximately 82% of ware potatoes were stored in boxed stores, the remaining 18% in bulk stores.

**Figure 5 - Storage methods used for ware potatoes in the United Kingdom[1]**




**[1] Please note - All Pie-Charts within this report should be read clockwise from the top, as both the pie segments and the contents of the key appear in the same order.**

***Ware potatoes – Pesticide Usage***

| Active substance | Total tonnes treated | Active substance (tonnes applied) |
|---|---|---|
| Spearmint oil | 1,638,407 | 103.12 |
| Ethylene | 504,623 | . |
| Imazalil | 5,959 | 0.08 |
| Thiabendazole | 11 | <0.01 |
| **Total** | **2,149,001** | **103.20** |

Spearmint oil was applied as a hot fog in applications made by contractors during the storage period. Ethylene was applied as a gas throughout the storage period with its concentration monitored and maintained in store to prevent sprouting of tubers. Both active substances were applied as sprout suppressants, replacing the use of chlorpropham since the 2018 survey.

There was limited use of both imazalil and thiabendazole in ware potato stores. Both were used for disease control, with control of dry rot being specified for imazalil.

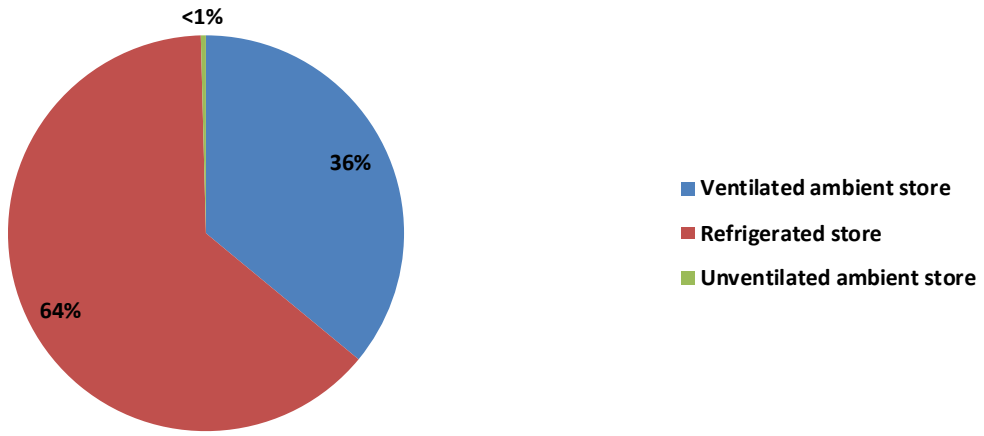
**SEED POTATOES**

- **An estimated 506,108 tonnes of seed potatoes were stored in the United Kingdom (this figure is based on GB November seed stock figures produced by AHDB combined with estimates from Northern Ireland)**
- **16,363 ha of seed potatoes were grown in the United Kingdom in 2020**
- **An estimated 163,127 tonnes were treated with a single pesticide application, although of these, 10,501 tonnes were treated with a tank mix of two products, one containing imazalil the other thiabendazole**
- **A further 342,981 tonnes (68%) remain untreated (66% of these in refrigerated stores)**

***Seed potatoes – Storage methods***

All seed potatoes encountered in the survey were stored in boxes.

**Figure 6 - Storage methods used for seed potatoes in the United Kingdom - 2020**




***Seed potatoes – Pesticide Usage***

Three pesticide formulations (imazalil, thiabendazole and ethylene) were the only pesticides encountered in seed potato stores accounting for 88%, 7% and 5% of the total treated tonnage respectively.

| Active substance | Total tonnes treated | Active substance (tonnes applied) |
|---|---:|---:|
| Imazalil | 152,632 | 2.02 |
| Thiabendazole | 12,214 | 0.37 |
| Ethylene | 8,782 | . |
| **Total** | **173,628** | **2.39** |

Imazalil and thiabendazole formulations were applied as sprays for disease control – normally on the elevator as the seed potatoes entered store. Dry rot, silver scurf, gangrene and skin spot were the principal diseases specified.

Ethylene gas was encountered in seed potato stores for the first time in 2014 and has been observed in all surveys since then. It is used to manipulate sprout development in refrigerated stores.

**APPENDIX 1 – DISTRIBUTION OF SAMPLED STORES**

| **Table 1.** ***Number and distribution of ware and seed potato stores sampled in the United Kingdom - 2020*** | | |
|---|---|---|
| | **Farm Stores** | **Merchant Stores** |
| | | |
| **Region** | | |
| | | |
| East Midlands | 7 | 10 |
| Eastern | 13 | 16 |
| London & South East | 2 | 1 |
| North East | 0 | 1 |
| North West | 1 | 4 |
| Northern Ireland | 2 | 0 |
| Scotland | 6 | 75 |
| South West | 3 | 3 |
| Wales | 1 | 1 |
| West Midlands | 5 | 2 |
| Yorkshire & the Humber | 5 | 15 |
| | | |
| **Total** | **45** | **128** |

**APPENDIX 2 - WARE POTATOES**

Throughout all tables, "." indicates that there was no recorded weight of either crops stored or pesticides used.

**Table 2.** ***Storage methods used for ware potatoes stored in the United Kingdom, 2020 (tonnes stored)***

| | Unventilated | Ventilated | Refrigerated | Total |
|---|---|---|---|---|
| Bulk storage | . | 439,219 | 128,673 | 567,892 |
| Boxed storage | . | 425,844 | 2,102,350 | 2,528,194 |
| **Total - all storage methods** | **.** | **865,063** | **2,231,023** | **3,096,086** |

**Table 3.** ***Storage pesticide use on ware potatoes at stores in the United Kingdom, 2020 (tonnes treated)***

| | *Unventilated ambient* | | *Ventilated ambient* | | *Refrigerated* | | *Total* | | *All storage methods* |
|---|---|---|---|---|---|---|---|---|---|
| | ***Bulk*** | ***Box*** | ***Bulk*** | ***Box*** | ***Bulk*** | ***Box*** | ***Bulk*** | ***Box*** | |
| ***Chemical*** | | | | | | | | | |
| Ethylene[1] | . | . | 91,931 | 22,667 | 96,501 | 293,524 | 188,432 | 316,191 | 504,623 |
| Imazalil | . | . | . | 2,773 | | 3,186 | | 5,959 | 5,959 |
| Spearmint oil | . | . | 477,468 | 558,229 | 57,142 | 545,569 | 534,610 | 1,103,798 | 1,638,407 |
| Thiabendazole | . | . | . | 6 | . | 6 | . | 11 | 11 |
| **Total** | **.** | **.** | **569,399** | **583,674** | **153,643** | **842,285** | **723,042** | **1,425,959** | **2,149,001** |
| **Not treated** | **.** | **.** | **163,126** | **238,399** | **6,562** | **1,510,691** | **169,689** | **1,749,090** | **1,918,779** |

**Table 4.** ***Usage of individual active substances on stored ware potatoes in the United Kingdom, 2020***

| | Tonnes treated | Tonnes (active substance) | % tonnes | % active substance |
|---|---|---|---|---|
| ***Chemical*** | | | | |
| Ethylene[1] | 504,623 | . | 23 | . |
| Imazalil | 5,959 | 0.08 | <1 | <1 |
| Spearmint oil | 1,638,407 | 103.12 | 76 | 100 |
| Thiabendazole | 11 | 0.00 | <1 | <1 |
| **Total** | **2,149,001** | **103.20** | | |

[1]There is no standard recommended rate per tonne of potatoes for the use of ethylene. The application equipment is pre-set to maintain the required level of ethylene concentration in each store. Consequently, the quantity of ethylene used will vary according to the store capacity, crop volume, the quality of store construction and the duration of storage. In most cases the actual amount of ethylene used was not available and it was not considered appropriate to include the information available from only a limited number of stores.

**APPENDIX 3 – SEED POTATOES**

| **Table 5.** ***Storage pesticide use on seed potatoes in the United Kingdom, 2020 (tonnes treated)*** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Unventilated Ambient** | | **Ventilated Ambient** | | **Refrigerated** | | **Total** | | **All storage methods** |
| | **Bulk** | **Box** | **Bulk** | **Box** | **Bulk** | **Box** | **Bulk** | **Box** | |
| | | | | | | | | | |
| ***Chemical*** | | | | | | | | | |
| Ethylene[1] | . | . | . | . | . | 8,782 | . | 8,782 | 8,782 |
| Imazalil | . | . | . | 66,708 | . | 85,924 | . | 152,632 | 152,632 |
| Thiabendazole | . | . | . | 1,732 | . | 10,482 | . | 12,214 | 12,214 |
| **Total tonnage treated** | . | **.** | . | **68,440** | . | **105,188** | . | **173,628** | **173,628** |
| | | | | | | | | | |
| **Not treated** | **.** | **2,083** | **.** | **114,577** | **.** | **226,320** | **.** | **342,981** | **342,981** |
| | | | | | | | | | |
| **Total tonnage stored** | . | **2,083** | . | **182,142** | . | **321,883** | . | **506,108** | **506,108** |

| **Table 6.** ***Usage of individual active substances on stored seed potatoes in the United Kingdom, 2020*** | | | | |
|---|---|---|---|---|
| | **Total tonnes treated** | **Tonnes (active substance)** | **% tonnes** | **% active substance** |
| | | | | |
| ***Chemical*** | | | | |
| Ethylene[1] | 8,782 | . | 5 | . |
| Imazalil | 152,632 | 2.02 | 88 | 84 |
| Thiabendazole | 12,214 | 0.37 | 7 | 16 |
| | | | | |
| **Total** | **173,628** | **2.39** | | |

[1]There is no standard recommended rate per tonne of potatoes for the use of ethylene. The application equipment is pre-set to maintain the required level of ethylene concentration in each store. Consequently, the quantity of ethylene used will vary according to the store capacity, crop volume, the quality of store construction and the duration of storage. In most cases the actual amount of ethylene used was not available and it was not considered appropriate to include the information available from only a limited number of stores.

**APPENDIX 4 - COMPARISON**

| **Table 7.** ***Comparison of production, storage and treatment of potatoes in the United Kingdom - 2006-2020*** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **2006** | **2008** | **2010** | **2012** | **2014** | **2016** | **2018** | **2020** |
| **Area grown (ha)** | Ware | 128,212 | 131,475 | 120,873 | 131,825 | 123,317 | 120,707 | 127,859 | 126,704 |
| | Seed | 14,788 | 15,380 | 17,440 | 16,946 | 17,214 | 16,733 | 16,478 | 16,363 |
| **Tonnes stored** | Ware | 3,841,724 | 4,106,855 | 3,896,359 | 2,952,083 | 3,098,269 | 3,454,294 | 3,003,620 | 3,096,086 |
| | Seed | 417,371 | 457,996 | 509,803 | 457,519 | 422,591 | 550,582 | 563,652 | 506,108 |
| **Basic tonnes treated**[1] | Ware | 1,791,136 | 1,906,591 | 2,034,962 | 1,681,507 | 1,435,552 | 1,071,307 | 1,298,686 | 1,177,314 |
| | Seed | 152,025 | 144,984 | 171,007 | 115,969 | 168,884 | 250,770 | 97,751 | 163,127 |
| **Total tonnage treated**[2] | Ware | 3,183,264 | 4,045,106 | 3,807,290 | 2,907,145 | 2,677,280 | 1,623,981[4] | 2,435,656 | 2,149,001 |
| | Seed | 154,829 | 160,254 | 171,007 | 120,593 | 168,884 | 250,770[4] | 109,013 | 173,628 |
| **Tonnes untreated**[3] | Ware | 2,050,588 | 2,200,264 | 1,861,397 | 1,270,576 | 1,662,717 | 2,382,987 | 1,704,934 | 1,918,779 |
| | Seed | 265,346 | 313,012 | 338,796 | 341,550 | 253,707 | 299,812 | 465,901 | 342,981 |
| **Weight applied (tonnes)** | Ware | 55 | 42 | 37 | 31 | 36 | 20[4] | 29 | 103 |
| | Seed | 2 | 2 | 5 | 3 | 6 | 6 | 2 | 2 |

[1] Basic tonnes treated = tonnes stored – tonnes untreated

[2] Total tonnage treated = basic tonnes treated x number of treatments

[3] Tonnes untreated = potatoes stored which receive no pesticide treatments during storage

[4] This figure has been updated since the 2016 report was published

**APPENDIX 5 – INTENDED USE OF WARE POTATOES**

| **Table 8.** ***Pesticide use on the different types of ware potatoes encountered in the United Kingdom, 2020*** | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | **Chipping** | **Crisping** | **Canning** | **Fresh market** | **Other uses** | **Total** |
| | | | | | | |
| Ethylene | 229,248 | 8,226 | . | 223,461 | 43,688 | 504,623 |
| Imazalil | . | . | . | 1,462 | 4,497 | 5,959 |
| Spearmint oil | 252,703 | 835,585 | . | 352,224 | 197,893 | 1,638,406 |
| Thiabendazole | . | . | . | . | 11 | 11 |
| | | | | | | |
| **Treated tonnage** | **481,951** | **843,811** | **.** | **577,148** | **246,090** | **2,148,999** |
| | | | | | | |
| **Tonnage stored** | **420,849** | **412,585** | **4,570** | **2,014,359** | **243,723** | **3,096,086** |

As can be seen from Table 8, almost two thirds, 65%, of all ware potatoes were intended for the fresh market, 14% for chipping, 13% for crisping and less than 1% for canning.

Other intended uses accounted for 8% of the total tonnage of ware potatoes stored. The majority of these, 80%, were intended for processing, including mash, pasties, peeling and waffles, with 11% for stockfeeding and the remaining 9% were of unknown use.

Whilst the limited tonnage of canning potatoes remained untreated, spearmint oil and ethylene were the most extensively used active substances on chipping, crisping and fresh market potatoes. Most crisping potatoes were treated with spearmint oil, rather than ethylene.

## APPENDIX 6 - METHODOLOGY

### METHODS

The samples of holdings to be surveyed were selected using data from the Agricultural Census Returns, June 2019 for England & Wales (Anon., 2020 a, b), for Scotland (Anon., 2020c) and Northern Ireland (Anon, 2020d).

The samples for the arable survey (Lewis et. al., 2021) were drawn from the census returns to represent the area of all arable crops grown throughout England, Scotland, Wales and Northern Ireland. For England the sample was selected within each of the eight Government Office Regions (GORs). The Welsh Assembly Government provided a further sample, which represented the area grown in Wales. For Scotland the country was divided into 11 land-use regions (Wood, 1931). For Northern Ireland the sample was selected to represent the distribution of crops in Northern Ireland.

The samples for the arable survey were stratified according to the total area of all arable crops grown in each region and by farm size group based on the total area of arable crops on each farm. The area of arable crops sampled in each size group and each region was proportional to the total area of arable crops grown on holdings of each size group in each region. All three survey teams followed the same methodology for data collection and used the same forms and instructions for their completion. The size groups, based on the total arable area are as follows: <50ha (A); >50-<=100 ha (B); >100-<=150 ha (C); >150-<=250 ha (D); >250-<=500 ha (E) and >500 ha (F).

In England and Wales, most of the data on arable pesticide usage was collected by a sub-contractor, using the sampling frame and stratification methodology indicated above. Whilst the sub-contractor collected detailed field pesticide usage, they did not collect supplementary data on potato storage.

To increase the data relating to potato storage in England and Wales a separate sample was taken using the same stratification indicated above (region and arable farm size group), but only from holdings who indicated on their 2019 June Survey returns that they were growing potatoes. A total of 665 holdings were selected and an introductory letter was sent to each, explaining the purpose of the survey and enclosing a postal reply form requesting the total area of arable cropping, the area of potatoes grown and the tonnage of potatoes stored from the 2020 harvest.

Of the 132 positive responses received in England & Wales, 84 grew potatoes with 39 of these storing potatoes on the farm (an additional 7 farms declined to participate in the survey). All respondents growing and storing potatoes in 2020 were contacted by telephone to confirm the types of stores and storage treatment details. Of the 39 growers storing potatoes, 37 provided storage information. The other two were moved to the merchant address list as they were growing on farms other than their own.

Of the 84 farms growing potatoes, 29 rented land to other growers. These growers were also contacted and those providing information became part of the merchant address list as they were storing potatoes grown on their own and other farmers land.

The Pesticide Survey Unit at SASA provided information on 6 farm and 75 merchant potato stores in Scotland.

The Pesticide Usage Survey Team at AFBI provided data on a further 2 farm potato stores in Northern Ireland.

A further questionnaire was sent to 73 merchants' stores in England & Wales, of which storage data were received from 53. No responses were made from the remaining 20.

***Estimated tonnage stored***

Data were raised to estimate national pesticide usage (Thomas, 1999). The raising factor used for ware potatoes was based on November GB potato stock movement information provided by AHDB Potatoes (Anon, 2021). Additional data were not available from Northern Ireland because of Covid issues and the 2018 data were used to calculate a United Kingdom figure.

As the AHDB estimates are derived from a sample of 300 growers, it was necessary to account for the stores where no growing of ware potatoes was involved, and where the storekeepers bought directly from growers. For England & Wales, this consisted of 6 of the 53 merchant stores. These 6 stores comprised 12% of the total sampled tonnage stored and the estimated tonnage for England & Wales derived from the AHDB figures was multiplied by 1.12 to give a revised figure that included stores not growing potatoes.

Two separate raising factors were used for seed potatoes (see below), which were based on the AHDB Potatoes November GB potato stock movement for seed potatoes. Additional data were not available from Northern Ireland because of Covid issues and the 2018 data were used to calculate a United Kingdom figure.

Following discussions with colleagues in Scotland, it was agreed that a separate raising factor for seed potatoes be used for Scotland and another for the rest of the United Kingdom. Scotland stores 79% of the estimated seed potato tonnage in Great Britain, based on the AHDB figures, and therefore a separate Scottish raising factor is logical for this crop. In Scotland, raising factors for seed potatoes are based on the regional areas of potatoes grown and divided by the sampled areas in each region. Using a single United Kingdom raising factor for seed potatoes led to an underestimate of the use of imazalil and thiabendazole on seed potatoes. Using a specific raising factor for Scottish seed potatoes ensured that the values for imazalil were closer to the SASA estimates, but still underestimated the use of thiabendazole in Scottish stores (although thiabendazole has a lesser usage compared to imazalil). A similar issue occurred in the 2018 survey.

Raising factors for ware potatoes were calculated by dividing the United Kingdom estimated tonnage stored by the sampled stored tonnage. For ware potatoes the raising factor was 3.7, for Scottish seed potatoes 2.9 and for the combined England, Wales and Northern Ireland seed potatoes, 2.4. For each calculation and to estimate quantities stored and pesticides applied, the raising factors used were to six decimal places.

The raising factors used have assumed that the sampled stores and their pesticide usage are representative of potato stores in the United Kingdom, and that the AHDB estimates are without error. We appreciate that the absence of absolute figures for the tonnages of seed and ware potatoes in the United Kingdom, such as those available from the June Survey figures for cropping areas, does present a challenge when estimating national usage.

This issue is unlikely to improve in the future as potato growers have voted to discontinue the statutory levy payments to AHDB potatoes. No further updates to the 'GB potato stocks' web pages (https://ahdb.org.uk/potato/stocks) were made after the 2nd of July 2021.

***The Questionnaire***

The questionnaire consisted of two forms, which were completed by an experienced surveyor during a telephone interview with the farmer, or for commercial stores, by a store representative following receipt of a comprehensive set of instructions.

Form 1 summarised the area of potatoes and arable crops grown on each holding during the 2020 growing season. It also indicated whether potatoes were stored and asked for contact details in order to follow up on storage information.

Form 2 detailed all aspects of pesticide usage in each store. A separate form was completed for each method of storage and treatment programme. Seed and ware potatoes were recorded separately.

Where necessary, further checks have been made to ensure that farm stores were only storing potatoes harvested from their own holding; this has been done following consultations with individual growers. In some cases purpose built stores may have been built in co-operation with individual merchants in order to store potatoes that they would ultimately purchase. These have remained as farm stores if the potatoes were only from their own holding.

In contrast to surveys conducted by the England & Wales survey team up to and including 2010, which were conducted mainly by visit, the 2020 survey for England & Wales was a combination of postal and telephone surveys. There are inherent problems with postal surveys, the main one of which is that response rates are unpredictable and can be quite low.

Visits to arable farms in England & Wales, including those with potato storage, are now limited as most arable data are collected by Kynetec (Lewis et. al., 2021). However, the aim of this survey was to obtain the number of farm stores similar to those achieved when farm visits were made. For on-farm potato storage in England & Wales a total of 665 letters were sent, assuming a 10% response rate to achieve a total of over 60 stores, which would then be in line with the numbers recorded for the last visit survey in 2010 (56 stores in England & Wales).

However, whilst a 20% response rate was achieved overall, only 6% of the total responses were from farms growing and storing potatoes (37 stores in total).

The send out to 665 England & Wales farms in 2020 resulted in 37 farm stores, compared to 55 stores in 2018 when 684 letters were sent out. This difference in response rates between 2018 and 2020 is possibly due to the Covid pandemic. There were similar patterns in Scotland, where the number of farm stores declined from 10 in 2018 to 6 in 2020, and Northern Ireland where the number of farm stores declined from 25 in 2018 to 2 in 2020.

***Rounding***

Due to the rounding of figures, the sum of constituent items in the tables may not agree exactly with the totals shown.

***Error checking***

Extensive checks are made on the data before, at the time of and following data entry. Data checking routines are used to verify the authenticity of the data collected including the authorisation and approval status of all crop/pesticide combinations, high and low rates of application, the methods of application used to apply pesticides, the timing of pesticide applications and untreated tonnages.

Further checks are made on the integrity of the relational database used to store the raw data collected ensuring that links to product databases are in place prior to the production of the report. The product databases used for the pesticide usage surveys are maintained alongside the commercial product database, *LIAISON*, which is used extensively by agronomists and the major farm management software companies.

Where inconsistencies are found, for example where there are high rates of application or non-approved product usage, these are checked first against the information collected and secondly with the grower and amended if necessary.

Reports are written and checked within the team after which they are sent to reviewers within the ECP Working Party on Pesticide Usage Surveys for their comments and checking.

The final report is pre-announced and published via the Government statistics release calendar and the Fera Science Ltd. website in line with the Code of Practice for Statistics.

***Data limitations and use of data***

Our experience has shown that the proposed face to face interview and 'main contact plus reserves approach' delivers the highest quality data and minimises non-response bias; no other approach is likely to yield fit for purpose data to meet the quality requirements of the UKSA Code of Practice for Official Statistics. Drawing a fresh stratified random sample each year is clearly an appropriate survey methodology.

Whilst there are detailed data available on the cropped areas of ware and seed potatoes in the United Kingdom there are no such figures for stored potatoes. The only data available on stored ware and seed potatoes are estimates produced by AHDB Potatoes for Great Britain and estimates produced by AFBI for Northern Ireland. In the absence of any other data it has been these figures that have been used to create raising factors and to make national estimates.

As part of this survey Fera Science Ltd. has implemented the United Kingdom Statistics Authority Code of Practice for Statistics, published in 2009 and revised in 2018. Whilst all three pillars and 14 principles apply, we acknowledge the following:

- Honesty and integrity: people in organisations that release statistics should be truthful, impartial and independent, and meet consistent standards of behaviour that reflect the wider public good.
- Data governance: organisations should look after people's information securely and manage data in ways that are consistent with relevant legislation and serve the public good.
- Efficiency and proportionality: statistics and data should be published in forms that enable their reuse. Producers should use existing data wherever possible and only ask for more where justified.
- Accessibility: statistics and data should be equally available to all, not given to some people before others. They should be published at a sufficient level of detail and remain publicly available.

In accordance with UKSA Code of Practice for Statistics, we work with Defra and HSE statisticians to build on our existing extensive and effective relationships with users of the surveys to further enhance user engagement. There is a broad spectrum of users and stakeholders across policy, research, agricultural supply industry (including consultancies), farming and horticultural businesses, civil society organisations and members of the public. Over the years we have an excellent record of listening to our users and incorporating their feedback into the way we collect and report our statistics.

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